Separators

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VA 95/4299/E

1. STATIC SEPARATORS

1.1 Cyclone

1.1.1 Principle of Operation

Air with dispersed material enters the cyclone through the inlet. Coarse particles precipitate at the wall due to centrifugal forces, while fine particles are carried with the air and leave the cyclone through the immersion tube.

1.1.2 Mechanical Elements

- immersion tube
- inlet volute and cylindrical section
- conical part
- discharge device (rotary valve, pendulum flap)

1.1.3 Dimensioning

Cyclone nominal diameter (rule of thumb)

$$\mathbf{d} = \sqrt{\frac{4 \cdot V}{n \cdot \pi \cdot 2.6 \cdot 3600}}$$

d	[m]	nominal diameter cyclone
V	[m^3/h]	total airflow
n	[n]	number of cyclones

1.1.4 Operation

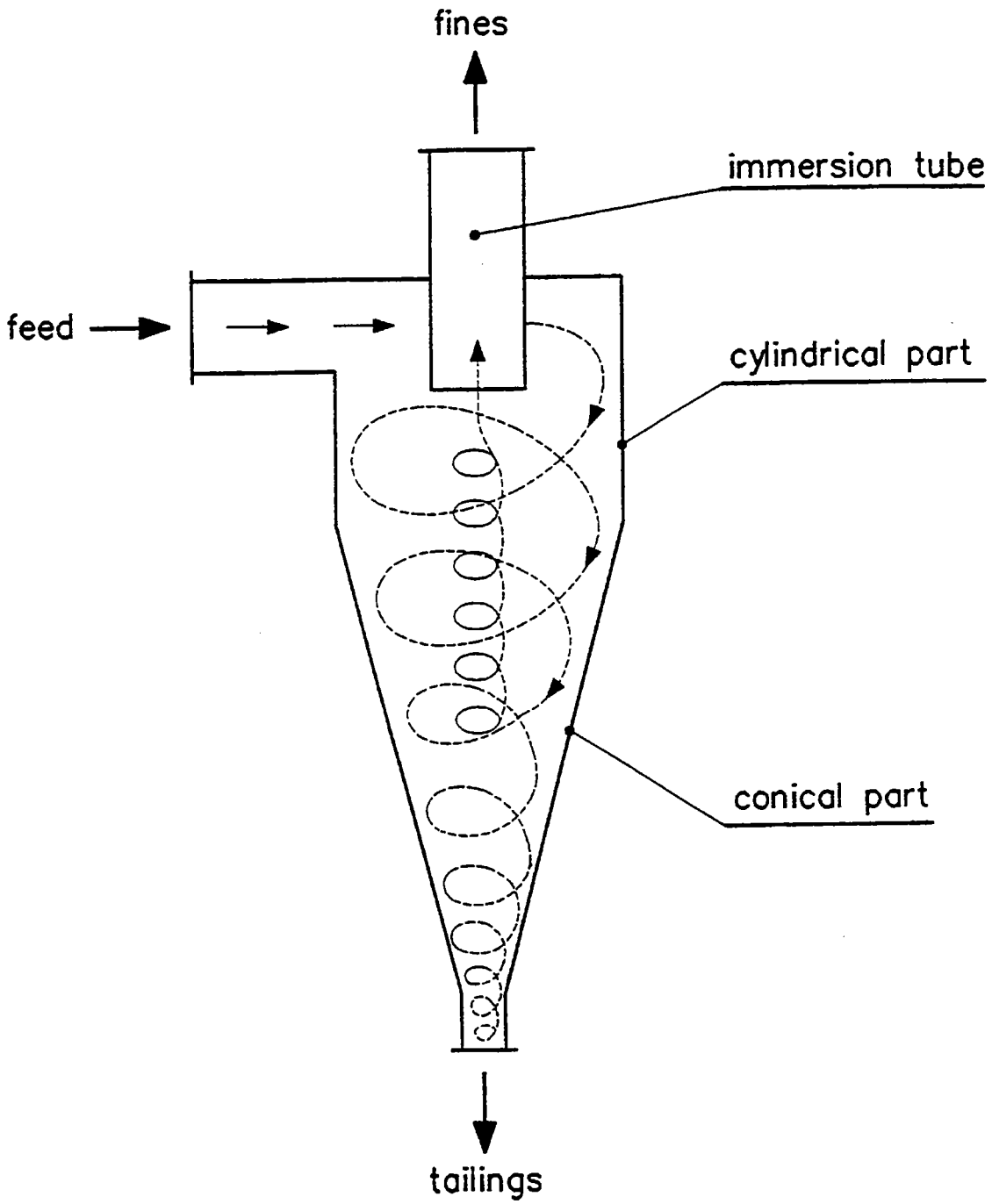
- pressure drop around 10 - 15 mbar, dedusting efficiency 75 - 80 %
- product fineness adjustment possibilities:
  - * diameter of immersion tube (smaller diameter - finer separation)
  - * immersion tube depth (longer tube - finer product)
  - * gas flow (higher flowrate - finer product, but higher pressure drop)

Applications

- air-swept tube mills
- roller mills
- hammer crusher-dryers, flash dryers
- cyclone-air dynamic separators (see 2.2)

1.1.5 Design

Figure 1 Cyclone



1.2 Grit Separator

1.2.1 Principle of Operation

Dust-laden air enters the separator from below and flows through a large number of adjustable blades. If the blades are set radially, coarse particles are precipitated only by the action of inertial forces since they cannot follow the 90 ° deflection of streamlines when entering the blades and the immersion tube.

If the guide vanes are set at an angle to the radial direction, a vortex motion of the fluid is created and separation due to centrifugal forces takes place. The effectivity of centrifugal separation is limited since the tangential velocity is not very large compared to the radial velocity.

If the angle is increased, the tangential velocity increases also and the cut size is lowered. At angles of around 60 ° the particles begin to hit the blade tips and due to friction the tangential velocity decreases.

This explains why with angles larger than about 60 ° the cut size goes up again and is generally limited to about 90 µm with this type of classifiers.

1.2.2 Mechanical Elements

- immersion tube
- adjustable blades
- blades adjustment ring
- tailings cone
- housing

1.2.3 Dimensioning

Specific air load (feed) 500 - 1000 g/m^3

$$\mathbf{d = 0.0127 \cdot \sqrt{V}}$$

d	[m]	nominal diameter
V	[m^3/h]	airflow

1.2.4 Operatin

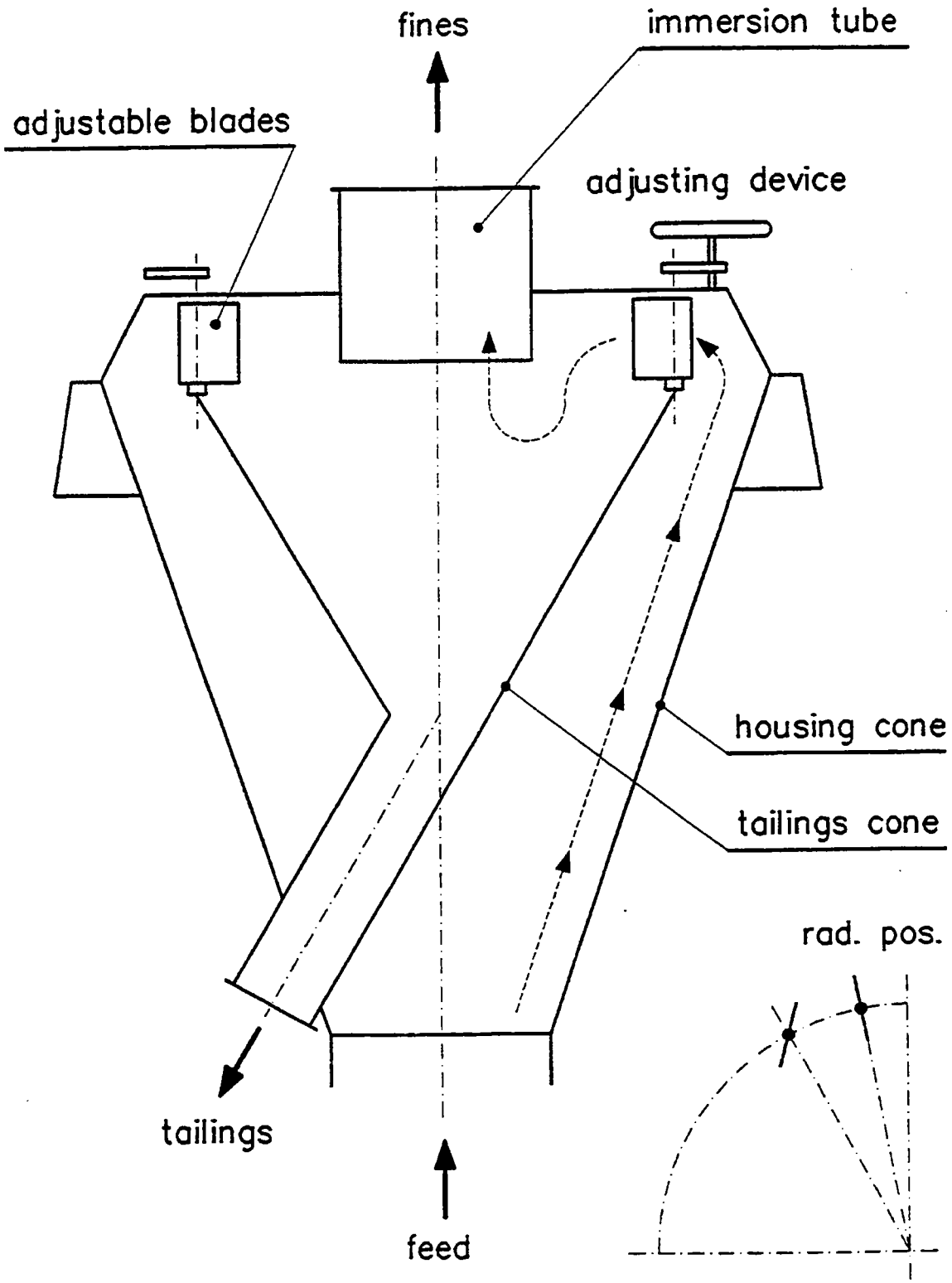
- Pressure drop 10 - 15 mbar, dedusting efficiency 75 - 80 %
- coarser product: shorten immersion tube, set blades radially
- finer product: lengthen immersion tube, set blades tangentially

Applications

- air-swept ball mills
- vertical roller mills
- hammer crushers

1.2.5 Design

Figure 2 Grit Separator



1.3 VS-Separator

1.3.1 Principle of Operation

The feed is admitted to the VS-Separator from above. The material flows through the classifying zone over inclined plates. Classifying air is introduced into the classifying zone transversely to this fresh material flow. The classifying air can consist of either circulating air, hot gases for drying or fresh air for cooling. The actual separation zone is located between the inclined plates and an array of baffle plates. The fines entrained by the air flow are moved through the space in between the baffle plates and discharged at the air exit opening.

Due to gravitational force the coarse fraction is discharged from the classifier in downward direction.

1.3.2 Mechanical Elements

- housing
- inclined plates four guiding the feed material with individually replaceable plates
- baffle plates for flow direction with individually replaceable elements
- air inlet/outlet box
- tailings outlet

1.3.3 Dimensioning

Guide values for 1700 cm^2/g product fineness in closed circuit with roller press:

- specific air load (feed) ~ 4 kg/m^3
- specific separator load ~ 6 m^3/s per m^2 projected open separating area
- designation: VS-459 → 4.59 m^2 projected open separating area

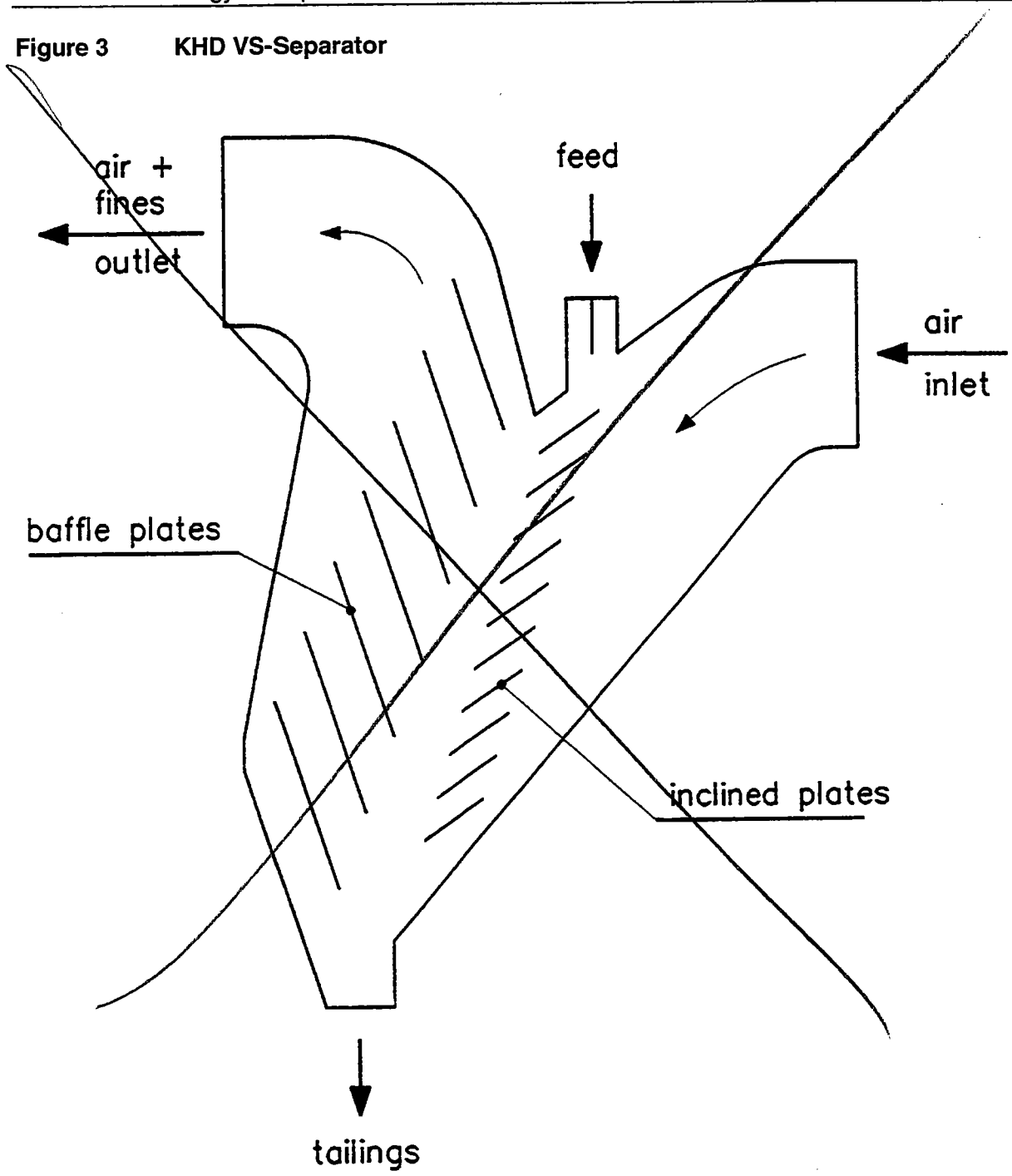
1.3.4 Operation

- Setting of a suitable air velocity enables control of cut size
- product fineness up to 4'500 cm^2/g is possible in finish grinding systems
- pressure drop 6 to 15 mbar

Applications

- high pressure comminution circuit with a roller press for clinker and raw material

Figure 3 KHD VS-Separator



2. DYNAMIC SEPARATORS

2.1 Classifiers with Counterblades and Internal Fan

2.1.1 Principle of Operation

Feed material is introduced through a chute onto a distributor plate that disperses the particles in the airflow. Air with dispersed particles flows up and passes the rotating counterblades. Coarse particles are centrifuged out to the surrounding wall and fall down into the tailings cone. Air with fines flows through the fan to the fines chamber. Here the fine material is separated from the conveying air and collected in the outer cone. Air together with some amount of fine material is returned to the separating zone through the air vanes.

2.1.2 Mechanical Elements

- housing
- feed spouts
- distributor plate
- counterblades
- internal fan
- return air vanes
- tailings cone
- fines collecting chamber
- fineness control valves (Sturtevant)
- gearbox and motor

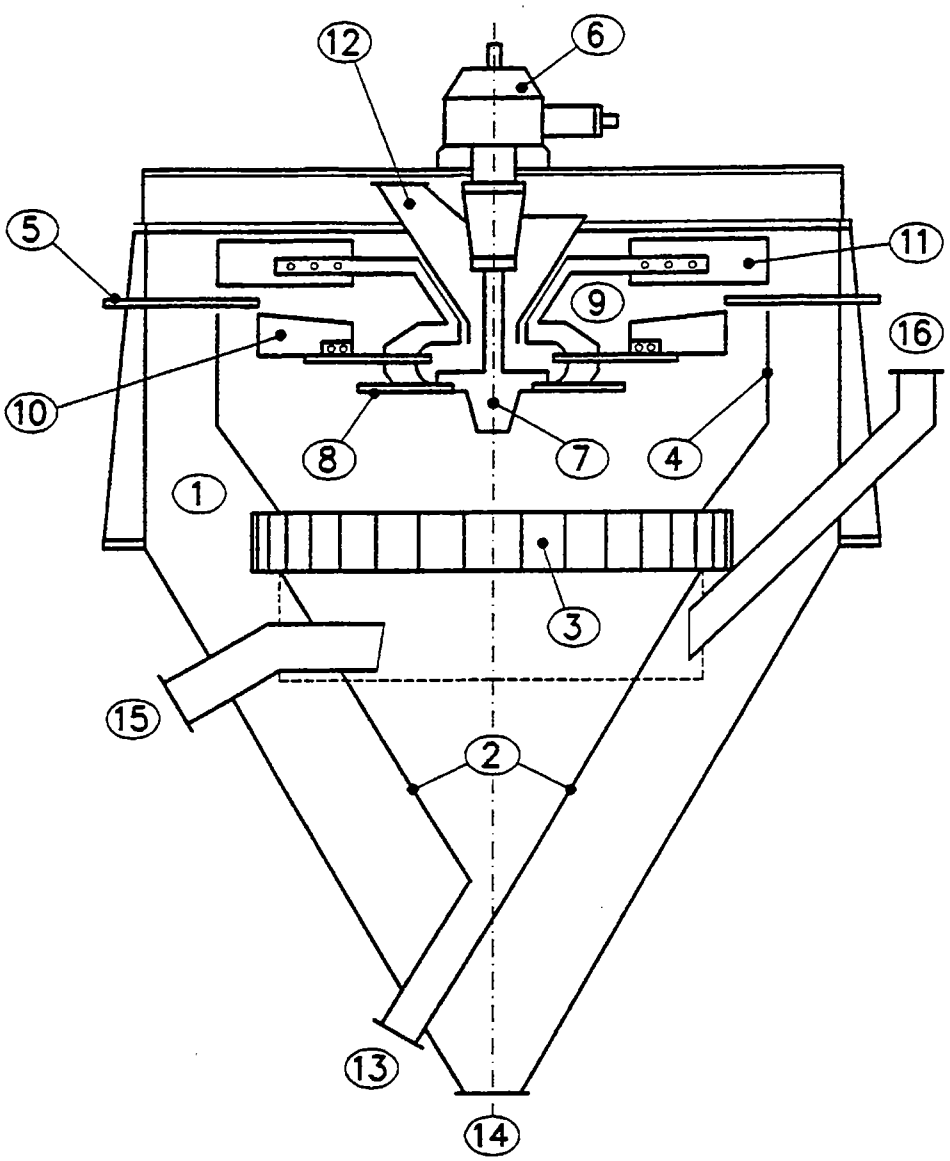
2.1.3 Dimensioning

Cement Fineness [cm^2/g]	**Specific Separator Load** [$t/h.m^2$]
~ 2500	2.2 - 3.6
~ 4500	1.0 - 1.5

$$\text{specific separator load} = \frac{finished\,product[t/h]}{nominal\,cross\,area[m^2]}$$

- the nominal cross section area refers to the outer diameter of the separator
- for large separators the higher values are applicable
- the indicated values are guide values and vary from supplier to supplier

Figure 4 Sturtevant Whirlwind Air Separator



1. fines chamber
2. tailings cone
3. air vane
4. inside drum
5. fineness control valve rod
6. gear reducer
7. main shaft and distributing hub
8. distributing plate
9. fan cone
10. counterblades
11. main fan blades
12. feed spout and intake cone
13. tailings outlet
14. fines outlet
15. air inlet
16. air outlet

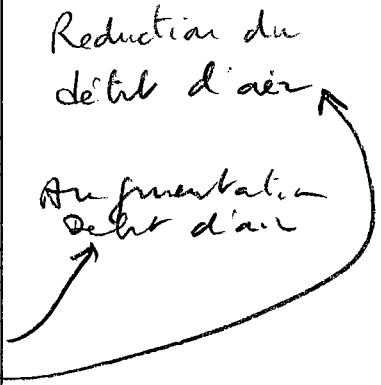
2.1.4 Operation

Fineness range 3000 - 6000 cm^2/g

Adjustment possibilities:

- speed of counterblades
- radial position, number and size of counterblades
- radial position of fan blades (Sturtevant, Raymond)
- radial position of fineness control valves (Sturtevant, Raymond)

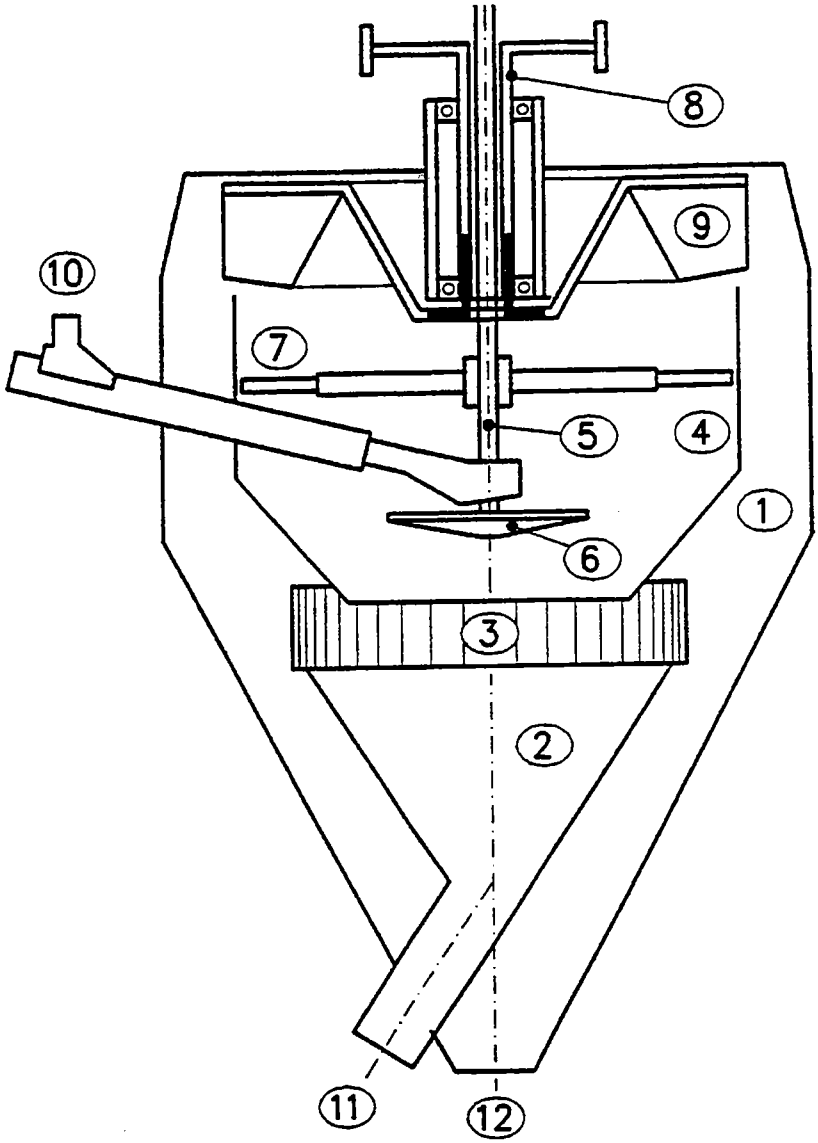
adjustment	**product fineness**
counterblades:	
increased speed	finer
increased number	finer
increased radius (moved outward)	finer
increased size	finer
fan blades:	
increased radius (moved outward)	coarser
internal fan damper:	
outward position (larger opening)	coarser
inward position (smaller opening)	finer



2.1.5 Design

- Sturtevant Separator (fig. 4)
  - the separator shown in fig. 4 has additional air inlets/outlets for drying/cooling purposes
  - similar makes: Raymond
- Heyd Separator (fig. 5)
  - the Heyd separator from Chr. Pfeiffer has two individual drives for fan and counterblades
  - (fixed speed for fan, variable speed for counterblades and distributor plate), this makes adjustment easier and improves the separator efficiency by fine grinding.
  - similar makes: Polysius (Turbopol), Fuller, Schmidt

Figure 5 Heyd-Type Separator



1. fines chamber
2. tailings cone
3. air vane
4. separation chamber
5. distributor+counterblades
6. distributor plate
7. counterblades
8. fan shaft
9. fan blades
10. feed spout
11. tailings outlet
12. fines outlet

2.2 Classifiers with Counterblades and External Fan

2.2.1 Principle of Operation

Material is introduced through feed spouts and dispersed in the circulating air by the rotating distributor plate. Particles fine enough to pass the rotating counterblades are conveyed by air to external cyclones where they are precipitated and discharged. Coarse particles move downward to the coarses cone. The air is recirculated to the separator via fan air vanes.

Inleaking false air is removed via dedusting filter and fan in order to maintain a constant underpressure inside the system.

2.2.2 Mechanical Elements

* housing
* feed spouts
* tailing cone
* distributor plate
* counterblades
* drive unit
* cyclones
* external fan
* additional ducts

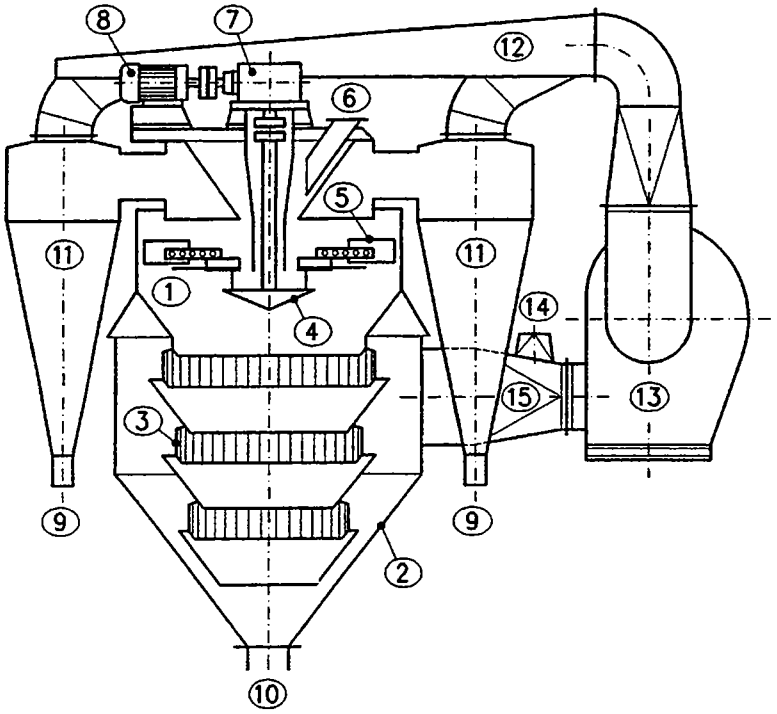
2.2.3 Dimensioning

Cement Fineness [cm^2/g]	**Specific Separator Load [$t/h.m^2$]**
2600	~ 11
3000	~ 8
4000	~ 5
4500	~ 4

$$\text{specific separator load} = \frac{finished\,product[t/h]}{nomin\,al\,cross\,sec\,tional\,area[m^2]}$$

The indicated values are guide values and vary from supplier to supplier.

Figure 6 Cyclone Air Separator (WEDAG)



① separation chamber
② tailings cone
③ air vanes
④ distributor plate
⑤ counterblades
⑥ feed spout
⑦ gearbox
⑧ motor
⑨ fines outlet
⑩ tailings outlet
⑪ cyclones
⑫ air duct to fan
⑬ fan
⑭ dust collecting pipe to filter
⑮ return air duct

2.2.4 Operation

Fineness adjustment possibilities:

- speed of counterblades
- number of counterblades
- airflow rate

adjustment	product fineness
counterblades:	
increased speed	finer
increased number	finer
fan damper:	
more open	coarser
more closed	finer
fan speed:	
higher speed	coarser
lower speed	finer

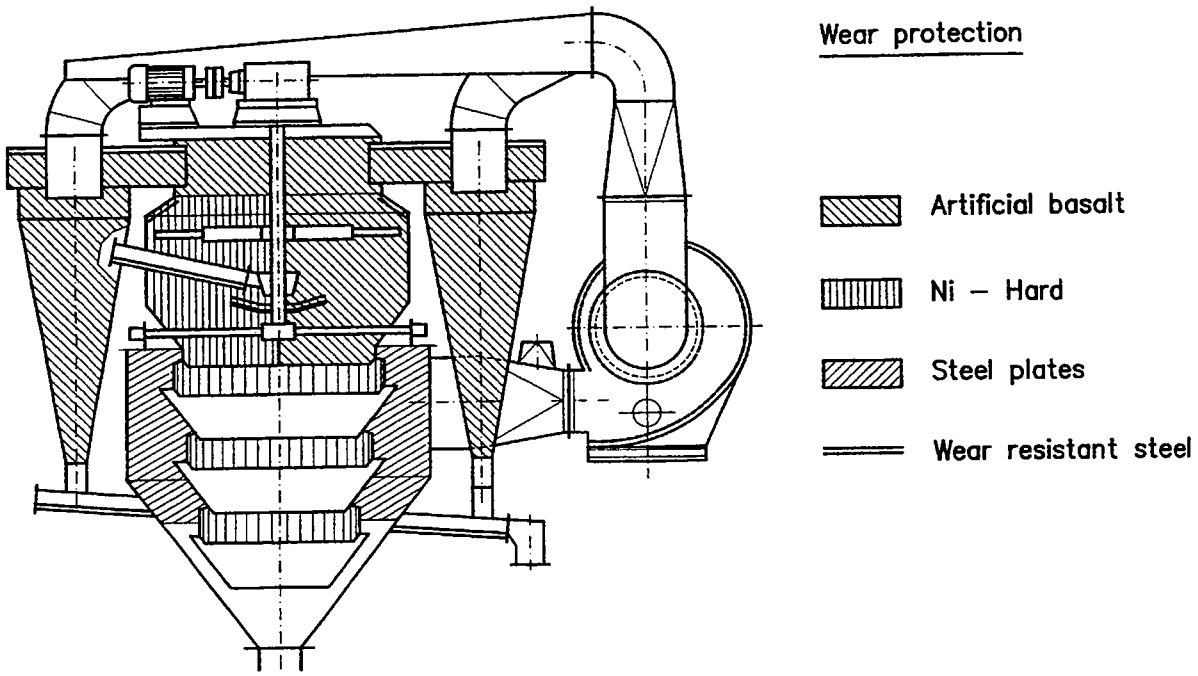
2.2.5 Design

Fig. 6 shows a Wedag ZUB separator with external air circuit and usually a number of planetary cyclones. In figure 7 a typical example for the wear-protection of separator parts is given for a Polysius Cyclopol separator.

The advantages of this type of classifier over the internal air circulation types can be summarized as follows:

- independent adjustment of separator speed and airflow gives a wider range of regulation and better fines separation efficiency because of more circulating air and lower particle concentrations
- a number of small cyclones gives a more efficient fines separation from the circulating air. This gives less fines in the return material and therefore a higher efficiency .
- fan runs in less dusty environment
- adjustment of fineness can be made without stopping the separator for change of counterblades

Figure 7 Cyclone Air Separator (Polysius Cyclopol)



2.3 Classifiers with Rotor Cage and External Fan (High-efficiency separators)

2.3.1 Principle of Operation

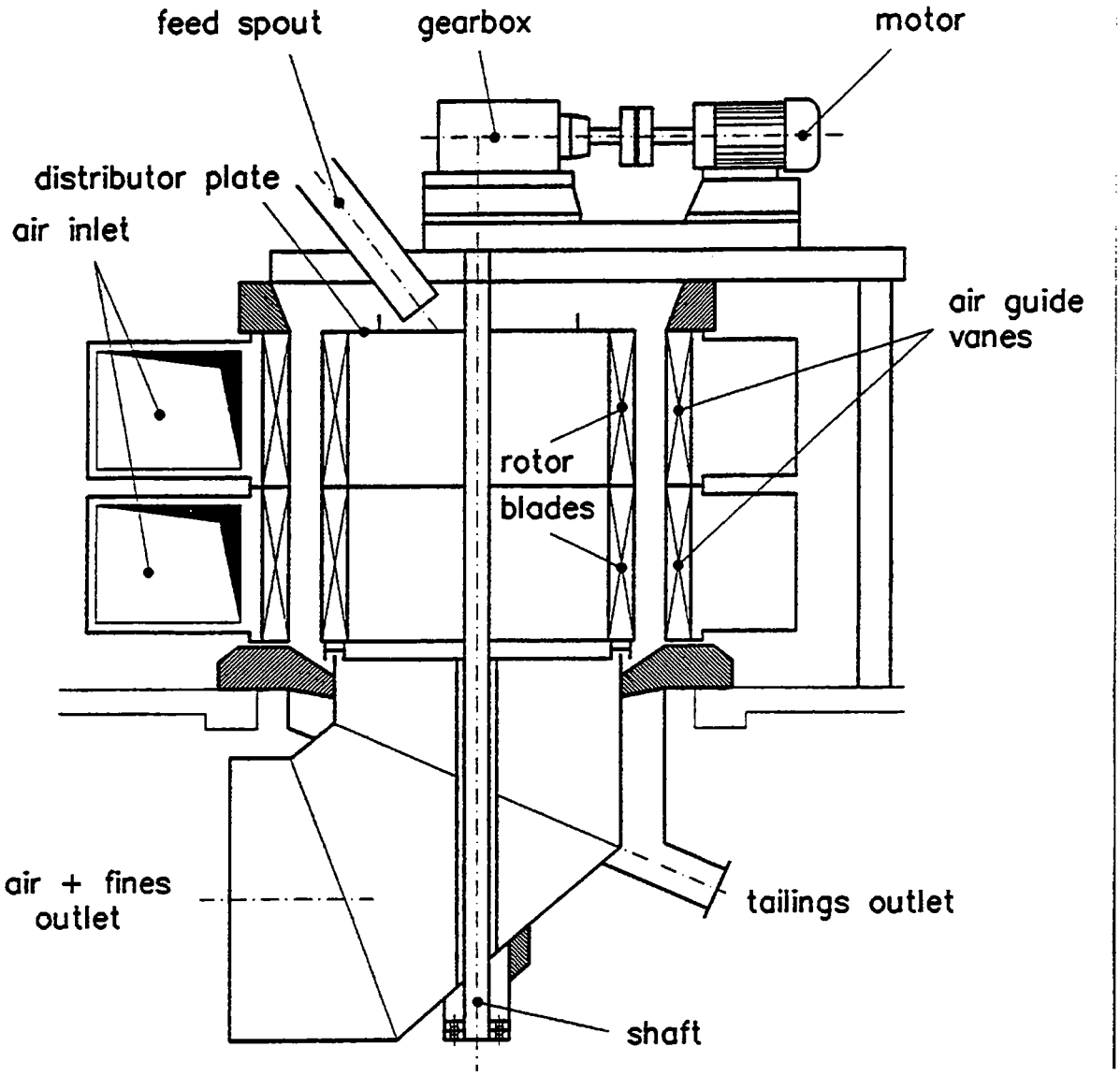
The central part is a rotating circular cage comprising a top distributor plate and a ring of vertical blades or rods that constitute the rejector.

Material is introduced through feed spouts and drops on the rotating dispersion plate on top of the rotor cage. From there it descends in the form of a circular curtain in front off the rotor blades. Air is introduced tangentially through guide vanes into the separating zone. Fine particles leave the separator with the air through the rotor and are precipitated in external cyclones or bag filter. Coarse particles are rejected by the rotor blades, pass the separation zone and leave the separator through the discharge device of the tailings cone.

2.3.2 Mechanical Elements

* feed chutes
* cage with rotor blades, shaft and distributor plate
* air inlet volute
* air guide vanes or conical louvre rings
* tailings outlet
* fines outlet
* gearbox and motor

Figure 8 O & K Cross-Flow Separator



2.3.3 Dimensioning

Dimensioning criteria for cement with around 3000 Blaine (see also fig. 9)

- specific rotor load ~ **10 - 12 t/h.m^2** or less
- specific air load (feed) **< 2.5 kg/m^3**
- specific air load (product) **< 0.75 kg/m^3**
- peripheral speed **5 to 35 m/s**, depending on Blaine
- specific installed power **0.4 - 0.5 kWh/t**

2.3.4 Operation

The separator is operated with constant airflow, fineness is controlled by the speed of the separator cage. Only in extraordinary cases where motor power or gearbox reduction ratio pose limits to separator speed, the airflow may be decreased to obtain the desired fineness.

To avoid dust emissions, it is mandatory to maintain a certain underpressure (around - 5 mbar) in the separator system. Since no ducting is perfectly tight, this underpressure causes an air inleak that has to be removed and dedusted by a filter. In case of single pass design this is the main dedusting filter. With cyclone air separators an additional dedusting filter has to be provided.

The recommended design value for the dedusting system air flow rate is 10 % of separating air amount.

Characteristic figures:

◆ installed separator	about 0.4 - 0.5	kWh/t
◆ installed fan power	about 2 - 2.5	kWh/t
◆ pressure drop across separator	20 - 25	mbar
◆ pressure drop across cyclones	about 10 - 15	mbar
◆ pressure drop across bagfilter	about 10 - 15	mbar
◆ pressure drop ducting	about 5	mbar

Figure 9 Rotor Type Separator

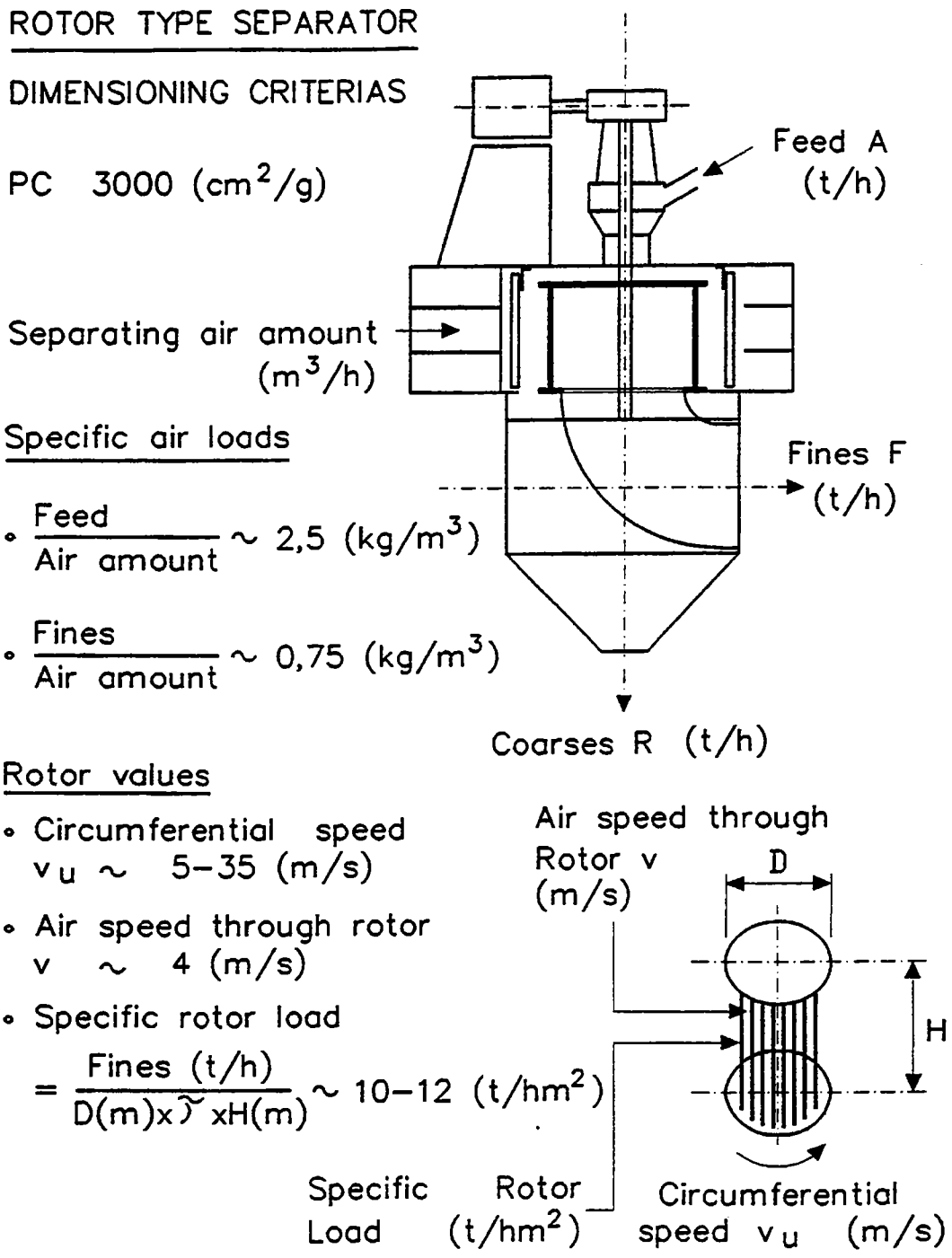


Figure 10 Fuller (Onoda) O-Sepa

Characteristics

Supplier **Type**	**Fuller (Onoda)** **O-Sepa**
Rotor: Diameter/Height	~ 1.7 : 1
Number of sep. air inlets primary air secondary air tertiary air	3 mill exhaust, ambient air ambient air air into cone
Number of sep. air outlets	1
Location air outlet	top of separator
Feed	central from top (2 or 4 inlets)
Fineness adjustment	rotor speed separating air amount
Standard sizes	12
Designation	N-500 ↓ Separating air amount m^3/min.

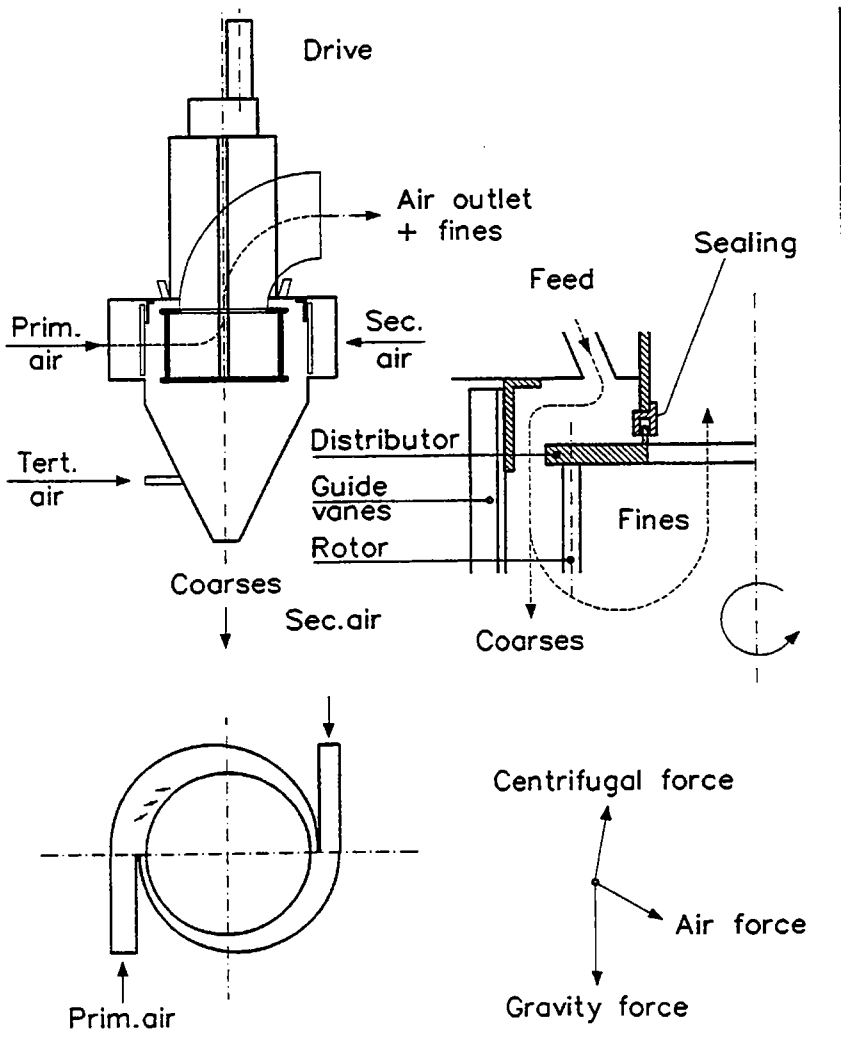


Figure 11 Polysius Sepol (Rotor Type Separator, Makes)

Characteristics

Supplier **Type**	**Krupp-Polysius** **Sepol**
Rotor: Diameter/Height	1.5 : 1
Number of sep. air inlets	1
Number of sep. air outlets single pass with cyclones	depending on system 1 1 to 6
Location air outlet	bottom part
Feed	central from top
Fineness adjustment	rotor speed separating air amount
Standard sizes	21
Designation	150 / 4 → number of cyclones ↓ rotor diameter [cm]

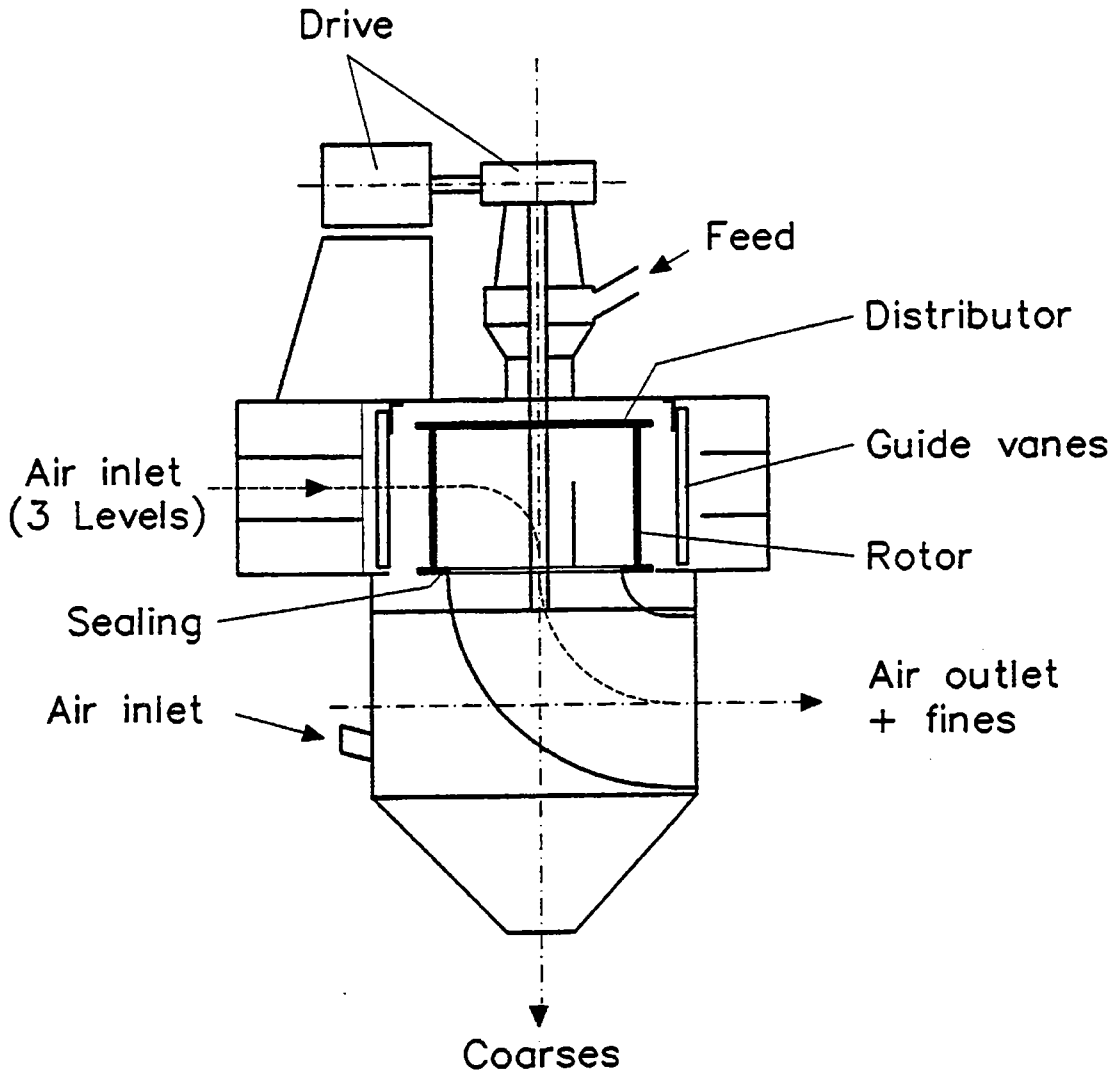


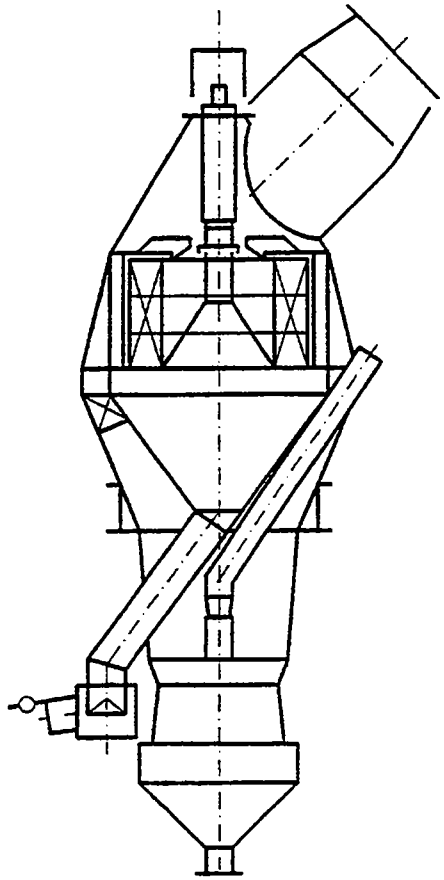
Figure 12 FLS Sepax

Characteristics

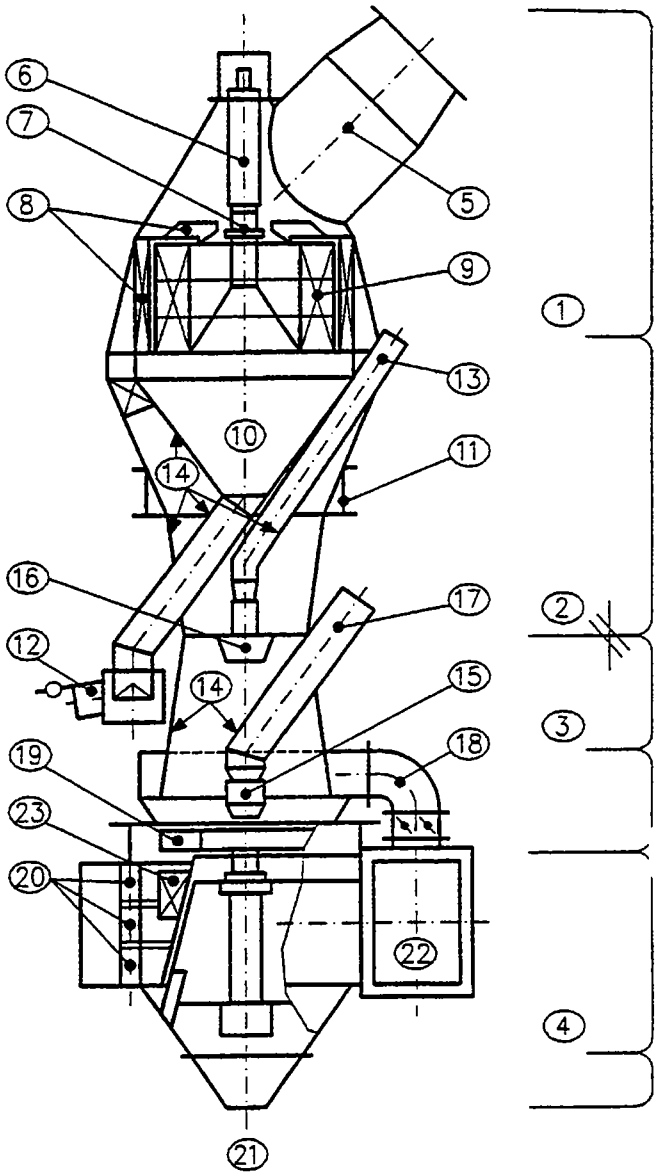
Supplier **Type**	**F.L. Smidth** **Sepax**
Rotor: Diameter/Height	~ 2.4 : 1 small separators ~ 1.2 : 1 large separators
Number of sep. air inlets	1
Number of sep. air outlets single pass with cyclones	depending on system 1 4
Location air outlet	top of separator
Feed	from bottom (dispersed in air/gas)
Fineness adjustment	rotor speed separating air amount
Standard sizes	17
Designation	Sepax 2 - 450 | | → diameter casing [cm] | → 2 with cyclones | → 1 single pass

The separator shown on the right of fig. 12 is equipped with integrated desagglomerator for application in roller press circuits.

compact version



integrated desagglomerator
(roller press applications)

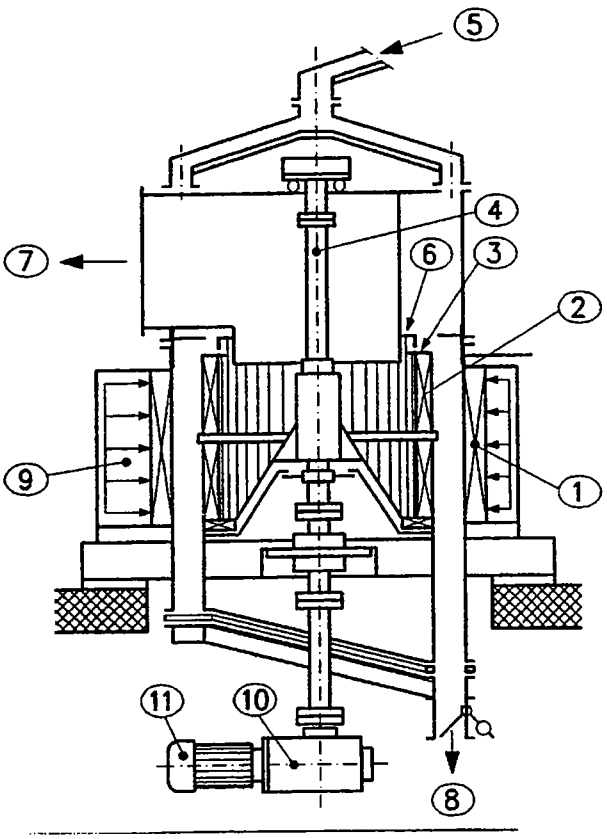


① separator part
② optional duct ext. to fit layout
③ desagglomerator
④ grit separator
⑤ fines outlet
⑥ bearing housing
⑦ shaft rotor joint
⑧ guide vane
⑨ rotor blade
⑩ reject cone
⑪ support
⑫ reject outlet valve
⑬ feed inlet
⑭ densit wearcast 2000
⑮ air lock
⑯ spreader plate
⑰ feed from press
⑱ air by-pass
⑲ desagglomerator rotor
⑳ guide vane sections
㉑ outlet to press
㉒ air inlet
㉓ rotor blades

Figure 13 KHD Sepmaster SKS - Z

Characteristics

Supplier **Type**	**KHD** **Sepmaster**
Rotor: Diameter/Height	~ 1.65 : 1
Number of sep. air inlets	1
Number of sep. air outlets single pass with cyclones	depending on system 1 2 to 8
Location air outlet	top of separator
Feed	central from top (SKS-Z, SKS-D) from bottom (SKS-LS)
Fineness adjustment	rotor speed separating air amount
Standard sizes	14
Designation	SKS 175 / 4 |→ number of cyclones



① guide vanes
② rotor blades
③ distributor plate
④ rotor shaft
⑤ feed spout
⑥ sealing
⑦ air + fines outlet
⑧ tailings outlet
⑨ air inlet
⑩ gear box
⑪ motor

Figure 14 KHD Sepmaster SKS-D and Sepmaster SKS-LS

KHD Sepmaster SKS-D

The design is specially tailored for closed-circuit operation with roller presses.

The sturdy desagglomerator is mounted directly above the separator and equipped with its own drive. Thus, both separator and desagglomerator can be individually adjusted for optimal performance.

KHD Sepmaster SKS-LS

The separator is laid out for material feeding together with air/gas.

It is applied mainly for combined drying and grinding of materials with high moisture content.

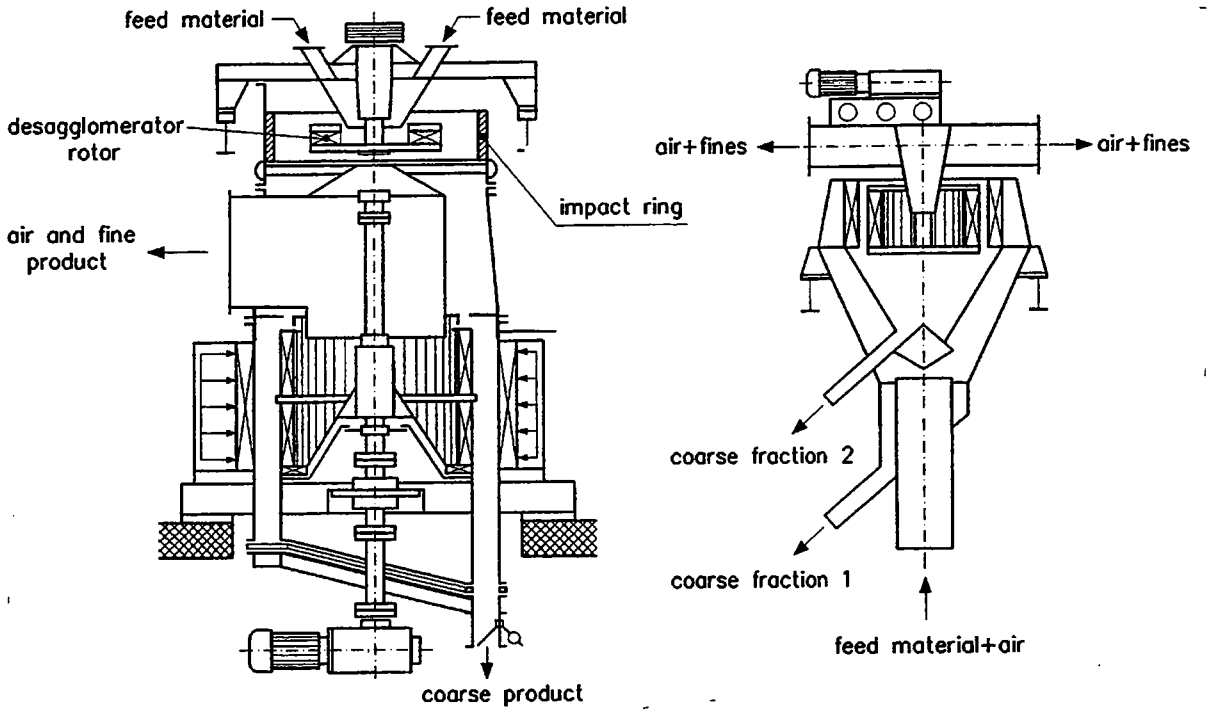
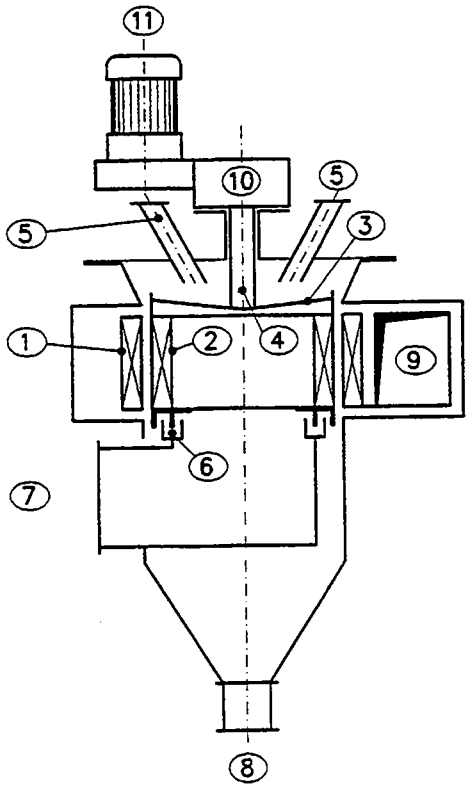


Figure 15 Pfeiffer QDK

Characteristics

Supplier **Type**	**Pfeiffer** **QDK**
Rotor: Diameter/Height	~ 1.5 : 1
Number of sep. air inlets	1
Number of sep. air outlets single pass with cyclones	depending on system 1 1 (cyclones installed separately) 1 to 8 (cyclones installed around sep.)
Location air outlet	bottom part
Feed	central from top
Fineness adjustment	rotor speed separating air amount
Standard sizes	17
Designation	11-N / 2 cyclones |→ diameter of separating zone [dm]



① guide vanes
② rotor blades
③ distributor plate
④ rotor shaft
⑤ feed spouts
⑥ sealing
⑦ air + fines outlet
⑧ tailings outlet
⑨ air inlet
⑩ gear box
⑪ motor

Figure 16 FCB TSV Classifier

Characteristics

Supplier **Type**	**FCB** **TSV**
Rotor: Diameter/Height	~ 4 : 1 small separators ~ 2.5 : 1 large separators
Number of sep. air inlets	1
Number of sep. air outlets	1
Location air outlet	top of separator
Feed	from top from bottom (feed dispersed in air/gas) mixed (top/bottom feed)
Fineness adjustment	rotor speed separating air amount
Standard sizes	16
Designation	TSV - 4000 |→ rotor diameter [mm]

The type with top feed is applied in e.g. bucket elevator ball mill circuits.
The type with mixed feed (top + bottom) is applied in e.g. grinding circuits with air-swept and semi-airswept tube mills and with the HOROMILL.

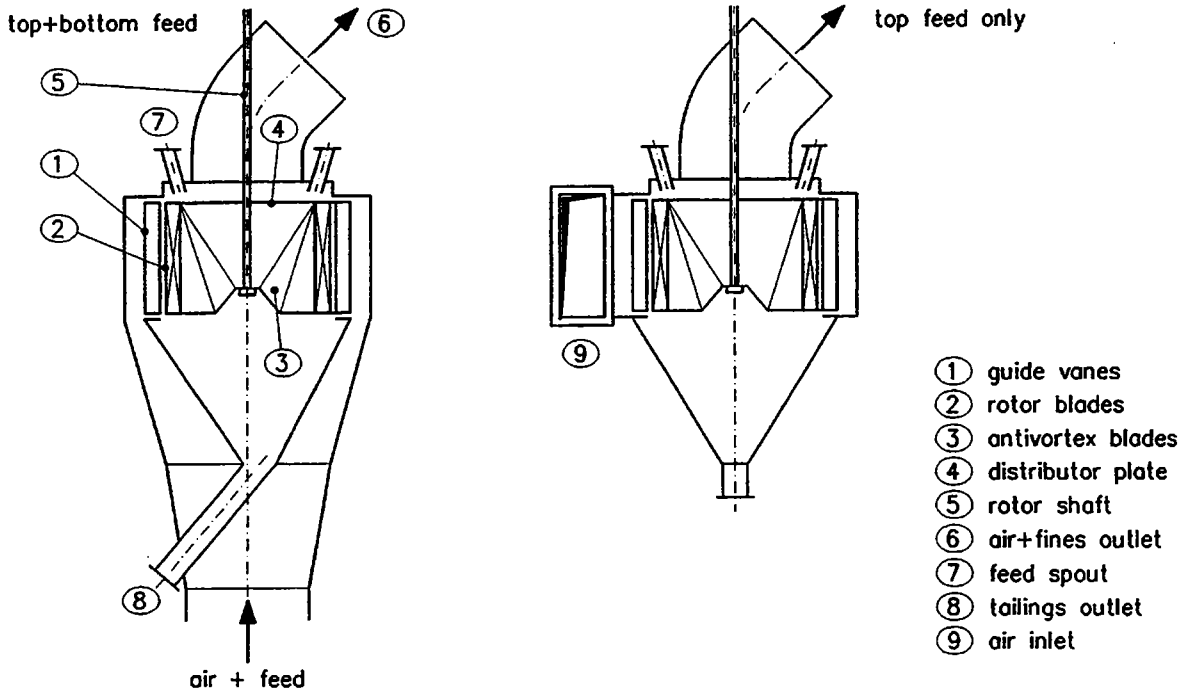
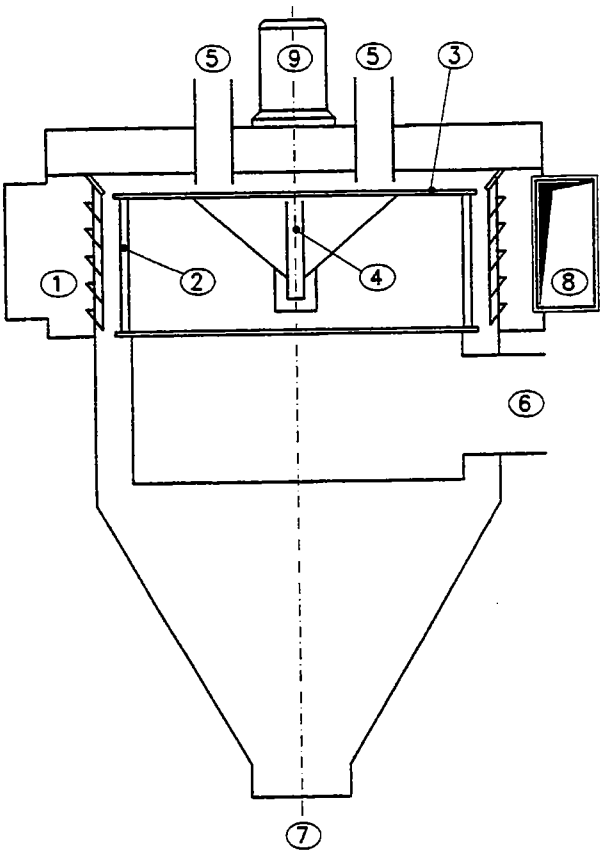


Figure 17 Sturtevant SD (Side Draft) Classifier

Characteristics

Supplier **Type**	**Sturtevant** **SD (Side Draft)**
Rotor: Diameter/Height	~ 1.3 : 1 small separators ~ 2.4 : 1 large separators
Number of sep. air inlets	1 to 8 1 with cyclones 8 with only fresh air
Number of sep. air outlets	depending on system
Location air outlet	bottom part
Feed	central from top
Fineness adjustment	rotor speed separating air amount
Standard sizes	10
Designation	SD - 20 - 4 | |→ number of cyclones |→ casing diameter [ft]



① conical deflector plates
② cage rods
③ distributor plate
④ rotor shaft
⑤ feed spouts
⑥ air + fines outlet
⑦ tailings outlet
⑧ air inlet
⑨ rotor drive

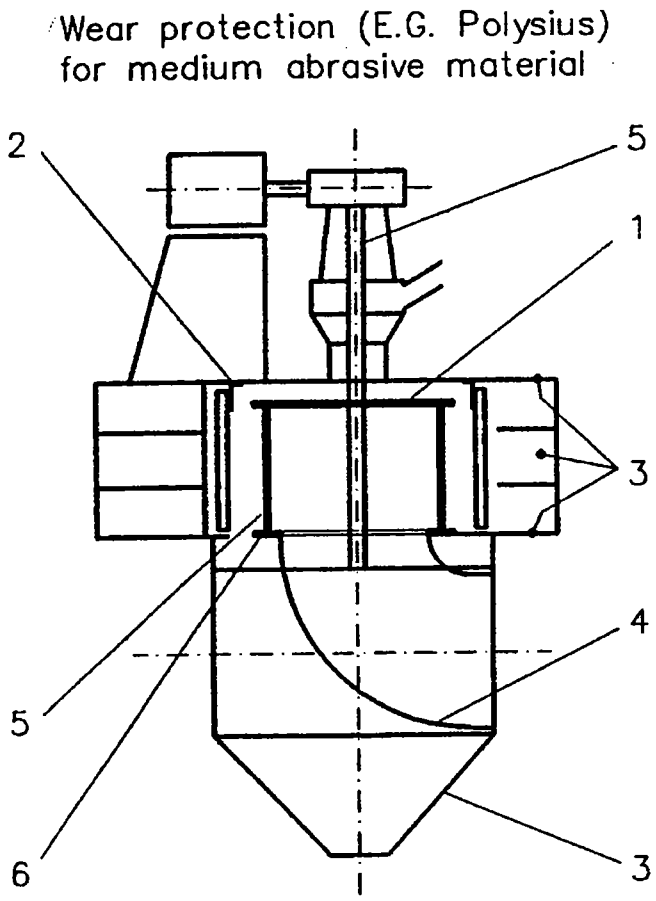
2.4 Wear Protection

The following parts of a rotor type separator are exposed to higher wear and require a protecting material or are manufactured of a wear-resistant material:

* air inlets
* air outlets
* distributor plate
* rotor
* drive shaft

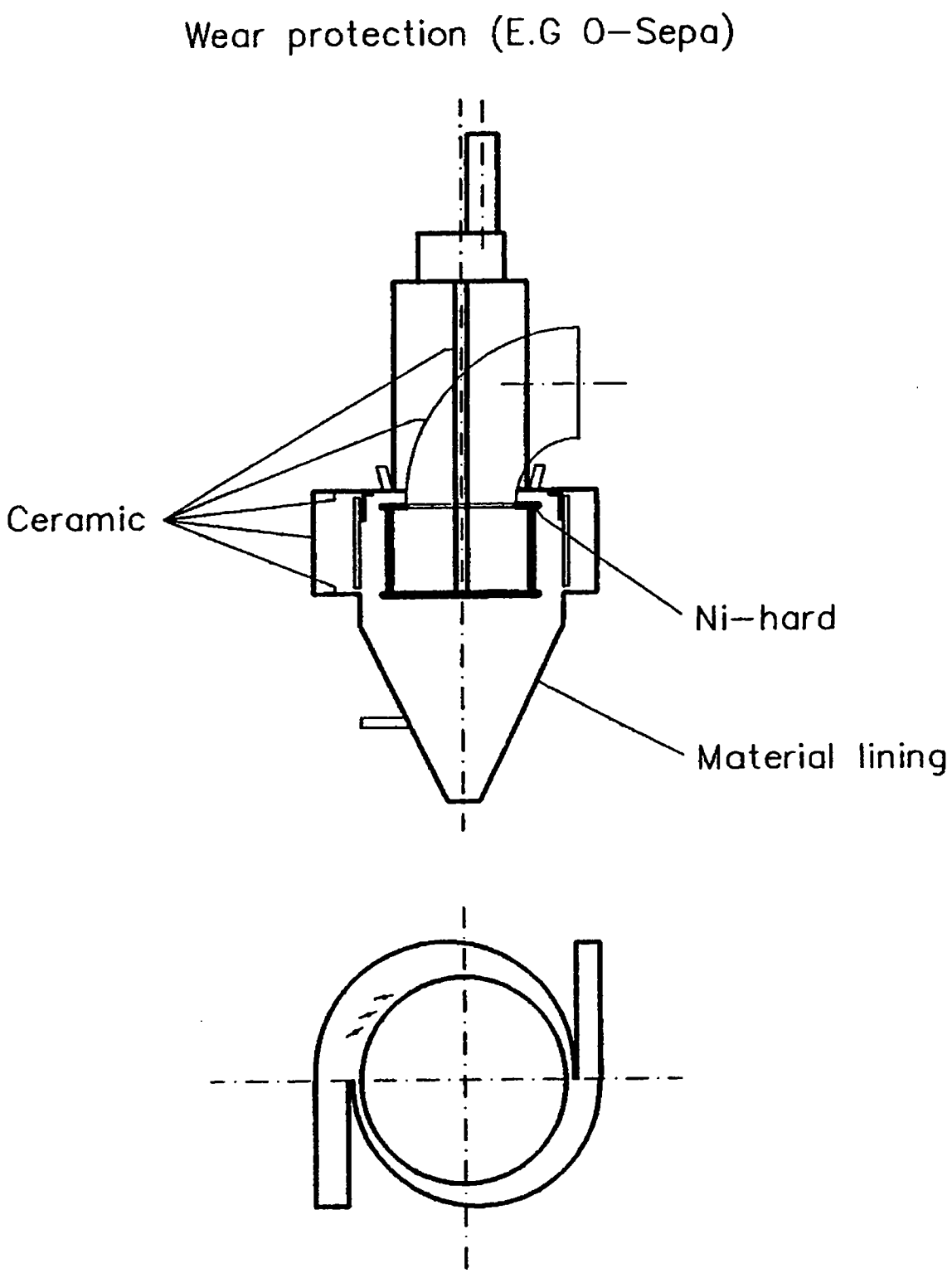
In fig. 18 typical examples for wear-protected parts are given for the Sepol separator from Polysius and the O-SEPA separator from Fuller.

Figure 18a Separator Wear Protection (e.g. Polysius) for Medium Abrasive Material



1 Compound steel plate (Duromax 260)
2 Vaudit, compound wear plate (mild steel + hard facing)
3 Tiscral
4 Basalt
5 St 37-2
6 Castolin, (hard facing)

Figure 18b Separator Wear Protection (e.g. O-Sepa)



2.5 Installation Arrangements

Basic solutions (fig. 19):

* cyclone air separator
* single pass separator with separate mill ventilation
* single pass separator combined with mill ventilation

Selection criteria:

* required cooling capacity
* condition of existing mill venting system
* available space
* investment and operating costs

	cyclone air separator	**single pass combined mill ventilation**	**single pass separate mill ventilation**
cooling effect	very low	medium	high
space requirement	approx. same as for mechanical separator	low for separator additional space requirement for bagfilter depends on capacity of existing mill filter	low for separator large bagfilter required
mill ventilation system	existing system is kept	depending on capacity and condition the existing mill filter is: replaced enlarged kept as it is	existing system is kept

Figure 19a Cyclone Air Separator

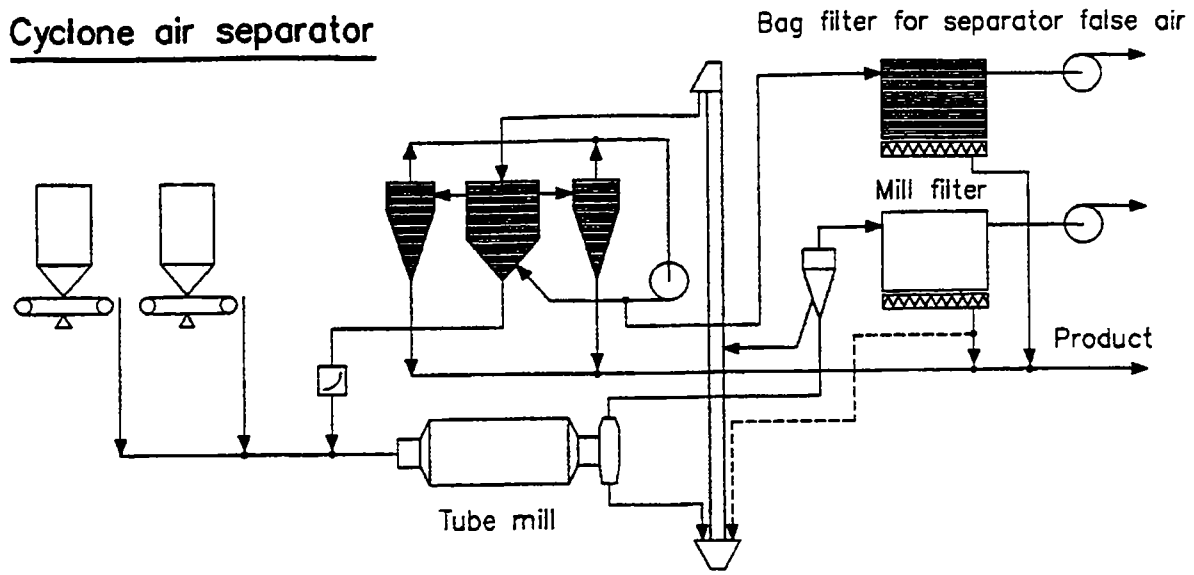


Figure 19b Single Pass Separator Combined with Mill Ventilation

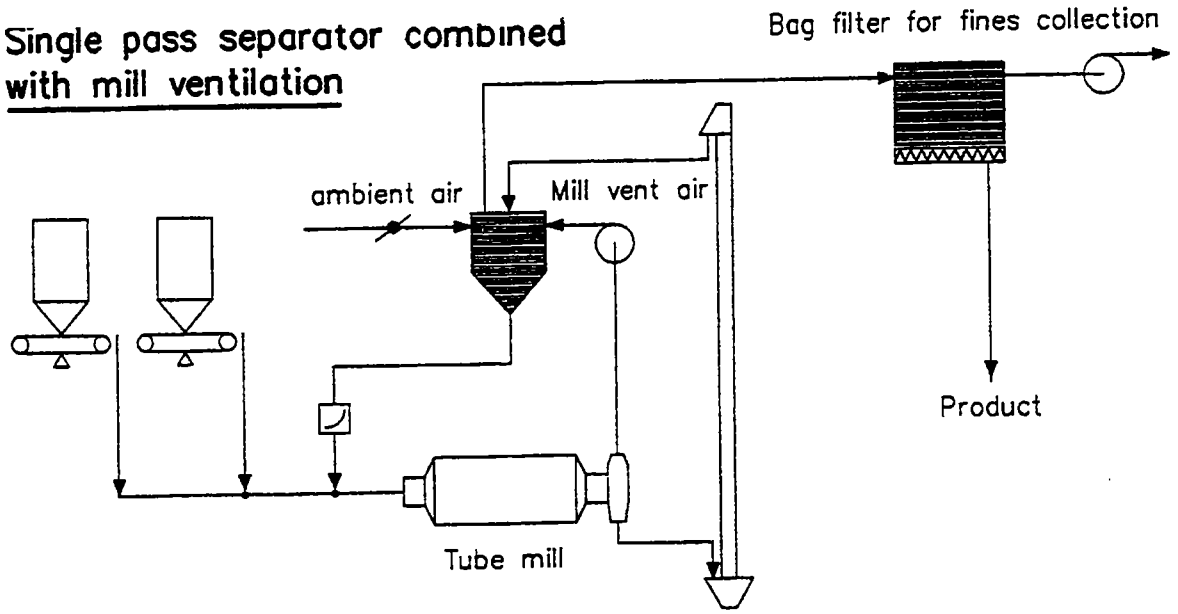


Figure 19c Single Pass Separator with Separate Mill Ventilation